Project Title:
Methyl Bromide Alternatives Research for Michigan Herbaceous Perennial Ornamental Production

Principal Investigator

Dr. George W. Bird, Professor
Department of Entomology
Room 243, Natural Science Building
Michigan State University
East Lansing, MI 48824
(517) 353-3890
(517) 353-4354 fax
birdg@msu.edu

Team Members:
George W. Bird, Nematologist, Dept. of Entomology, MSU
Bernie Zandstra, Weed Scientist, Dept. of Horticulture, MSU
Tom Dudek, MSU Extension, District Agent, Ottawa, Co.
John Davenport, Field Research Coord., G. W. Bird Lab.
Ponderosa Nursery, Hamilton, Michigan

Reporting Period
August 1, 2005 – January 31, 2006
Informal Progress Report for this One-Year Project
Final Report Due July 31, 2006

Proposal Synopsis
The MI herbaceous perennial ornamentals industry has relied on methyl bromide for nematode and weed management. This product is being phased-out under the Montreal Protocol. There is a distinct need for highly effective alternative nematode and weed management procedures. From the fall of 2002 through the fall of 2004, a 3.2 acre USDA-funded methyl-bromide alternatives trial was conducted at Sawyer Nursery in Hudsonville. Several potential alternatives were identified and the industry has requested that their efficacy and economics be demonstrated again at a second location. This proposal is designed to provide 2005-06 resources for this work at Ponderosa Nursery in Hamilton, Michigan. Although this is funded as a one-year project (August 1, 2005 through July 31, 2006) it will be continued throughout the 2006 and 2007 growing seasons.

Projected Impact on Michigan Nursery/Ornamental Horticulture Industry:
Nematodes and weeds are key pests in herbaceous perennial ornamental production in Michigan. With the phase-out of methyl bromide under the Montreal Protocol, it is imperative that effective and economically viable alternatives be identified and demonstrated to the producer community. The results of this research have the potential to significantly enhance the long-term quality, quantity and economics of the MI herbaceous perennial ornamentals production system. The project is well integrated with both the first (2002-2005) and second (2004 – 2007) Michigan herbaceous and woody perennial ornamental methyl bromide alternatives research grants obtained from USDA/CSREES. A summary of the first USDA project is attached as Appendix A.

Progress

The research consists of two field trials. The experimental designs are included as Figure 1 and Figure 2. The site at Ponderosa was sampled and staked out plots for the first time on October. 7, 2004. It was fumigated with 350 lbs 67/33 methyl bromide for trail II only Oct. 8, 2004. Both trials were sampled and fumigated with 350 lbs 67/33 methyl bromide for Trial I May 26, 2005, and Fumigated with 35 gallons Telone II per acre and trapped for Trial I on the same date. The soil at the site was tilled for both trials on July 27, 2005. Environmental conditions were far too dry to initiate the research at this time. Compost for both trials at 4 tons per acre and incorporated August 4, 2005. Trial I was planted on August 5, 2005, and Bio-Nema at 4.43 oz per acre in 47 gallons water per acre was also applied on this date, starting the irrigation within 15 minutes of the bio-nematicide treatment. Trial II was fumigated again with 400 lbs 67/33 methyl bromide per acre September 6, 2005. This was done because it had been worked and reworked to the point that the fumigated plots were very likely contaminated with both nematodes and weed seeds. Trial II was planted and treated with Vydate 2L post plant at 2 lbs. a. i. per acre in 25 gallons water per acre. The site was monitored numerous times during 2005 and is not ready for data observations and grower field days.

Figure l. Experimental design for methyl bromide alternatives Trial No. 1 at Ponderosa Nursery.

Treatments:

1 Control (cultivated and herbicides as needed)
2 Mulch and compost (4 tons per acre compost) Spot herbicides as needed
3 Bio-Nem
4 Methyl bromide (98-2 400 lbs. per acre taped)
5 Telone II (35 gallons per acre taped)

Clean stock, Hosta (lancifolia) and silver mound (artemisia) one row each
Four reps

301 1	302 4	303 3	304 5	305 2	401 5	402 1	403 2	404 4	405 3
101 5	102 4	103 2	104 3	105 1	201 4	202 2	203 1*	204 5	205 3

Road
North

Table 2. Experimental design for methyl bromide alternatives Trial No. II at Ponderosa Nursery.

Treatment:

1c: Control
2c: Mulch + Compost (spot herbicides as needed)
3c: Bio-Nem
4c: Chancellor
5c: Vydate

1m: Control
2m: Mulch + Compost (spot herbicides as needed)
3m: Bio-Nem
4m: Chancellor
5m: Vydate

Note:

C = no methyl bromide application
M = methyl bromide application
Cultivation and herbicides as needed

woods

401 5c	402 1c	403 4c	404 2c	405 3c	**406 1m**	**407 2m**	**408 3m**	**409 5m**	**410 4m**
301 1m	**302 2m**	**303 3m**	**304 4m**	**305 5m**	306 5c	307 2c	308 3c	309 4c	310 1c
201 3c	202 1c	203 5c	204 4c	205 2c	**206 5m**	**207 1m**	**208 4m**	**209 2m**	**210 3m**
101 5m	**102 1m**	**103 3m**	**104 4m**	**105 2m***	106 4c	107 3c	108 2c	109 5c	110 1c

Trial I
North

Appendix 1. MSU USDA/CSREES/Methyl Bromide Alternatives Project 1. Summary

Soil fumigation with methyl bromide (MB) is a major component of herbaceous and woody perennial ornamental production in Michigan for nematode and weed control. The practice is also commonly employed throughout the northeast and north central regions in tomato and strawberry production. The goal of this project was to identify alternatives for MB for use throughout the region and conduct grower education programs on MB, nematode management and weed management. The challenges associated with this task is extensive since it involves more than 1,900 different commodities, the majority of which have few or no non-fumigant herbicide registrations.

Nematodes

In a 3.2 acre commercial farm field experiment in Michigan (2002-04) with seven herbaceous perennial ornamentals, it was determined that methyl iodide 50% (MI) plus chloropicrin 50% (C), 300 lb/A; MI 98% plus C 2%, 150 lb/A; Telone (T) C-35, 35 g/A; T II, 35 g/A; T II, 35 g/A followed by metham sodium MS, 75 g/A; TC-35, 35 g/A followed by MS, 75 g/A; MB, 350 lb/A; MB 67% plus C 33%, 350 lb/a; MS, 75 gal/a and Basamid, 350 lb/A (B) provided excellent control of northern root-knot nematode (NRKN) for the duration of the research. MI 50% plus C 50%, 200 lb/A tarped and MS, 75 gal/A not tarped failed to provide NRKN control. Microplot trials were conducted in New York and Rhode Island (2003-05) for NRKN and root-lesion nematode (RLN) for tomato, strawberry and hosta. MB, 1lb/100ft^2; B, 350 lbs./A; Vydate L (V), 2.25 g /A; Fosthiazate (F), 4.8 pt /A; Agri-Mek (AM), 16 ozs/A, 2 applications; and BioYield^{TM} (BY), 3 g/plant were used.   MB provided excellent control of NRKN and significantly increased tomato yields, compared to the non-treated NRKN-infested control. NRKN eggs and root-galling were reduced by the F, V, B, AM and BY, but tomato yields were not enhanced. Tomato roots following MB were whiter than those associated with all other treatments. RLN was not recovered from soils or strawberry roots following MB or B application, and populations following F, V and AM, compared to the control. Susceptibility of hosta to NRKN was cultivar specific. Honeybell, Blue Cadet and Krossa Regal were resistant to NRKN. Honeybell was also highly tolerant to Southern RKN North Carolina Race 3.
Pre-plant (six week) soil applications of the butyric and propionic acids (BA, PA) and V were used for control of NRKN and RLN on tomato and strawberry, respectively under microplot conditions. BA at 1.0M and 0.5M resulted in >90% plant mortality. BA at 0.1M and V provided NRKN and RLN control. BA at 0.01M resulted in a three-fold reduction of RLN. Greenhouse trials demonstrated that pH is only partially responsible for the nematicidal activity of organic acids. The objective of the nematode biocontrol component of the project was to screen for the presence of NRKN fungal parasites in Michigan and the reaction of NRKN populations to Hirsutella minnesotensis (H), Pasteuria (P) and N-Viro Soil (NV).   In two field surveys, fungal parasitism 1-95% was observed in 37% of the samples, P occurring only once and H was never detected. In greenhouse trials on tomato, H SD3-2 reduced NRKN root densities 61-98% and exhibited nematode population specificity. The combination of H and NV resulted in greater nematode reduction compared to H alone, but not to NV alone. In NV dosage

trials on tomato under greenhouse conditions, there was both a dosage response and a consistent interaction with some NRKN populations responding more to NV than others. Similar work was completed with NV and three HG Types of Heterodera glycines. Response to 4g NV per 100 cc soil was more uniform in nematode suppression than 1g. The higher rate, however, exhibited phytotoxicity. The biotic and physio-chemical characteristics of the soils in the survey fields varied, suggesting NRKN populations may not all respond in the same way to MB alternatives.

Weeds

In the 3.2A field experiment, all of the treatments except MI + C, 200 lb/A, non tarped MS and Lactuca serriola in the B plots, all treatments provided good weed control for up to 20 months. Phytotoxicity was not observed for Echinops bannaticus 'Blue Globe', Lavandula angustifolia 'Hidcote Blue', Hosta 'Twlight PP14040', Artemisia schmidtiana 'Silver Mound', Chrysanthemum x superbum 'Snow Lady' and Coreopsis verticillata 'Moon Beam'. Minor injury occurred with Euphorbia polychrome. The negative impact of TC-35, 35 g/A on Euphorbia was the only effect of any of the treatments on plant dry weight.

Six treatments (Terbacil, 12 kg/ha; imazaquin, 0.42 kg/ha); flumioxazin, 0.28 kg/ha; isoxaben, 12 kg/ha plus trifluralin, 0.84 kg/ha; mesotrione, 0.28 kg/ha and trifloxysulfuron, 0.01 kg/ha were sprayed over the top of Pseudotsuga menziesii, Picea glauca densata, Picea glauca, Picea pungens glauca, Pinus strobes, Abies balsamea var. phanerolepis and Abies fraseri in a microplot and container trials three weeks after planting for weed control. Rimsulfuron, 0.025 kg/ha; imazapic 0.07 kg/ha and lactofen, 0.28 kg/ha included in the container trial. In the microplot trial, Terbacil, imazaquin, flumioxazin, isoxaben plus trifluralin, mesotrione, and trifloxysulfuron were safe on *P. pungens glauca*) and *P. strobus*) at 6 weeks after treatment and to white spruce *P. glauca*) in one of the two years. Terbacil injured *P. menziesii* and *P. glauca densata*, *A. fraseri* and *A. balsamea* var. phanerolepis). Mesotrione injured P. menziesii and flumioxazin injured A. fraseri in 2004. The only impact on plant growth was with P. glauca densata and A. fraseri treated with terbacil. Terbacil, imazaquin, flumioxazin and mesotrione gave the best weed control. Flumioxazin, however, did not control common lambsquarters and redroot pigweed in 2003, and mesotrione did not control common purslane either year. Results with Trifloxysulfuron and isoxaben plus trifluralin were variabale. Trifloxysulfuron controlled redroot pigweed in both years and common lambsquarters in 2004, while isoxaben plus trifluralin controlled common lambsquarters in 2004, eastern black nightshade, and broadleaf plantain in both years. In the container trial, Terbacil caused injury to all conifer species evaluated, except for A. fraseri and P. strobus in 2003. Contrary to the field experiment, almost all treatments caused injury on P. glauca densata and P. pungens glauca. The high injury is explained by a higher herbicide concentration in the soil media contained in the pots, making the herbicides more available for being absorbed by the seedlings. Mesotrione injured P. glauca in 2004 and lactofen injured P. strobus in both years. Terbacil significantly reduced seedling growth of A. balsamea var phanerolepis and A. fraseri. All treatments reduced the number of annual sowthistle, fall panicum, and carpetweed.

Ten ornamental species were evaluated in relation to six herbicides treatmetns under field conditions Terbacil, 1.12 kg/ha; imazapic 0.07 kg/ha; imazaquin 0.42 kg/ha; halosulfuron, 0.035 kg/ha; flumioxazin, 0.28 kg/ha; and isoxaben, 1.12 kg/ha plus trifluralin 0.84 kg/ha did not cause injury on *Ilex* 'Blue Prince'), *P. glauca*), A. yew and white cedar (*T.a occidentalis*) at 6 weeks after treatment. However, terbacil injured *Berberis thunbergii* 'Burgundy Carousel'), *Cornus stolonifera* 'Alleman's, *Euonymous alatus* 'Chicago Fire', *Hydrangea paniculata* 'Kyushu', *Spiraea japonica* 'Fire Light', and (*Syringa x prestoniae* 'Donald Wyman'. Imazaquin, imazapic, and halosulfuron had variable injury results among years and species. Flumioxazin and isoxaben plus trifluralin were the safest treatments on all species, except isoxaben plus trifluralin slightly injured euonymus. Imazaquin and imazapic caused reduced plant size index in dogwood. Terbacil had the best broadleaf weed control at 2 and 6 weeks after treatment. Imazaquin and flumioxazin effectiveness was comparable to terbacil at 6 weeks after treatment, with some exceptions. Imazaquin did not control common lambsquarters in 2003 and flumioxazin was less effective in controlling common lambsquarters in 2003, and common groundsel and common chickweed in 2004. Imazapic gave poor redroot pigweed and common lambsquarters control in 2003, but gave good control in 2004. Imazapic controlled all weeds evaluated and had acceptable control of common purslane and common groundsel at 6 weeks after treatment. Halosulfuron provided variable weed control among weed species. It had the best control on common groundsel, curly dock, and redroot pigweed in 2004; however, it gave only fair control of other weeds. Isoxaben plus trifluralin gave good control of common lambsquarters and redroot pigweed in 2004; control of the rest of the weed species was variable. These herbicides have the potential to replace MB for preemergence weed control in these ornamental crops.

Expected Impacts:

Herbicides are effective in controlling annual weeds in woody ornamental crops. Using herbicides in place of hand weeding should save Michigan nurseries over $3,000 per acre per year. All these fumigants, when applied correctly, have the potential to replace methyl bromide for weed control in perennial ornamental production. Between $1000 and $4,000 is spent per acre in hand weeding ornamental crops. The application of these fumigants can reduce significantly the expense of weed control among ornamental growers. Herbicides are effective in controlling annual weeds in conifer seedlings in containers and the field. Use of herbicides should save conifer seedling growers over $1000 per acre per year. Weed data were collected in June 2003, prior to planting and after chemical treatment to determine the effect of treatments on summer annual weeds. The 0.1M butyric acid treatment provided 95.2% weed control and was statistically superior to all other treatments. The 0.05 M butyric acid and propionic acid treatments provided 76.1 and 70.1% weed control and were statistically identical. The 0.01 M butyric acid, vydate and control treatments provided 7, 5.3 and 3.1% weed control and were statistically identical. Similar results were obtained from weed data collected during 2004, but on half as many replicate, resulting in less statistical significance.
The reason for this difference between MB and the other nematicides is not known and warrants further investigation. The study establishes valuable date base on: **a)** presence

or absence of fungal nematode biocontrol agents; **b)** what potential biological and abiotic soil amendment options the nursery and vegetable industries may test against RKN and *H. glycines* infestation; **c)** possible ecological basis to RKN pathogenecity differences; and **d)** avoiding the pitfalls of one-option-fits-all management approach through exploiting our ability to understand nematode parasitic variability.

Project Publications:

Melakeberhan, H. and G. R. Noel (2004). Response of selected *Heterodera glycines* populations to N-Viro Soil treatment. *Journal of Nematology* 36: 333-334.

Melakeberhan, H., S. Mennan, and S. Chen (2005). Possible effect of ecological adaptation on *Meloidogyne hapla* pathogenecity. *Journal of Nematology* 37: In press.

Melakeberhan, H., S. Mennan, and S. Chen (2005). possible effect of ecological adaptation on *Meloidogyne hapla* pathogenicity. *Journal of Nematology* 37: in press.

Mennan, S., S. Chen, and Melakeberhan, H. (2005). Suppression of *Meloidogyne hapla* populations by *Hirsutella minnesotensis* and N-Viro Soil. *Journal of Nematology* 37: In press.

Mennan, S., S. Chen, and Melakeberhan, H. (2005). Suppression of *Meloidogyne hapla* populations by *Hirsutella minnesotensis*. *Biocontrol Science and Technology* **000**, in press.